DETERMINATION OF THE GEOCENTRIC COORDINATES OF A STATION FROM THE INTERSECTION OF SPACE DIRECTIONS DETERMINED BY MEANS OF ARTIFICIAL SATELLITES

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The method for the simultaneity circle is used in the determination of the geocentric coordinates of a tracking station, by the intersection of two space directions in the Baker-Nunn network. The method is applied, for the directions 9010-9009 in order to compute the position of the tracking station 9009. $\Delta X = 54.0$ m, $\Delta Y = 4.7$ m and $\Delta Z = 17.6$ m is found for station 9009 by using 19 pairs, respectively 18 pairs of simultaneous observations. $\Delta X = 2.7$ m, $\Delta Y = 2.4$ m and $\Delta Z = 2.8$ m is found by applying the same method for the same directions computed in "Standard Earth" adjusted directions in the network.

The Bucharest Observatory developed a method of determining absolute space directions between two stations observing or tracking a satellite, using the simulatneity circle method [1]. This method was utilized in Europe for the determination of certain directions with the aid of satellite Echo I, and recently for the determination of the Nikolaev-Kario directions, Echo II and Pageos I were used. A. Passive geodetic satellites. In these determinations, the results of photographic observations were utilized, obtained with cameras of small and medium focal lengths, for example, NAFA, 25 cm.

Two problems are presented in this article.

The implementation of this method for the determination of space directions with the utilization of precise photographic observation of The Baker-Nunn network; the comparison of these results with the results obtained by SAO [2] is given.

The utilization of these space directions were the determination of geocentric coordinates of one station.

The determination of the Curacao Station coordinates were conducted by the use of space directions between stations Jupiter 9010/ - Curacao / 9009/ and Arequipa /9007/- Curacao / 9009/, determined by precise photographic observations of satellite Midas 4 1961-028-1 in the months of October and November in the year 1964 [3].

In this catalog [3] are given positions of satellites for the epoch 1950. In the time system AI and corrected for yearly aberrations. Transition to the TU I system was conducted by the VIN bulletins. The observations are corrected for time aberrations. Depending on four points of tracking, with the Lagrange Formula, there is obtained α and δ for the moment of simultaneity.

The average locations are calculated for 1964. 0 year with two approximations, the by the "Connaissance des Temps" in the "Independant Number Stars" method the precession nutation in the daily aberration was calculated in relationship with the reduction of quantities.

For these three stations the final coordinates were used from "Standard Earth" [2]. For each moment of simultaneous observations the position lines were calculated [4], which were performed with the aim of checking the calculations and observations presented graphically in drawing I for the direction 9007-9009.

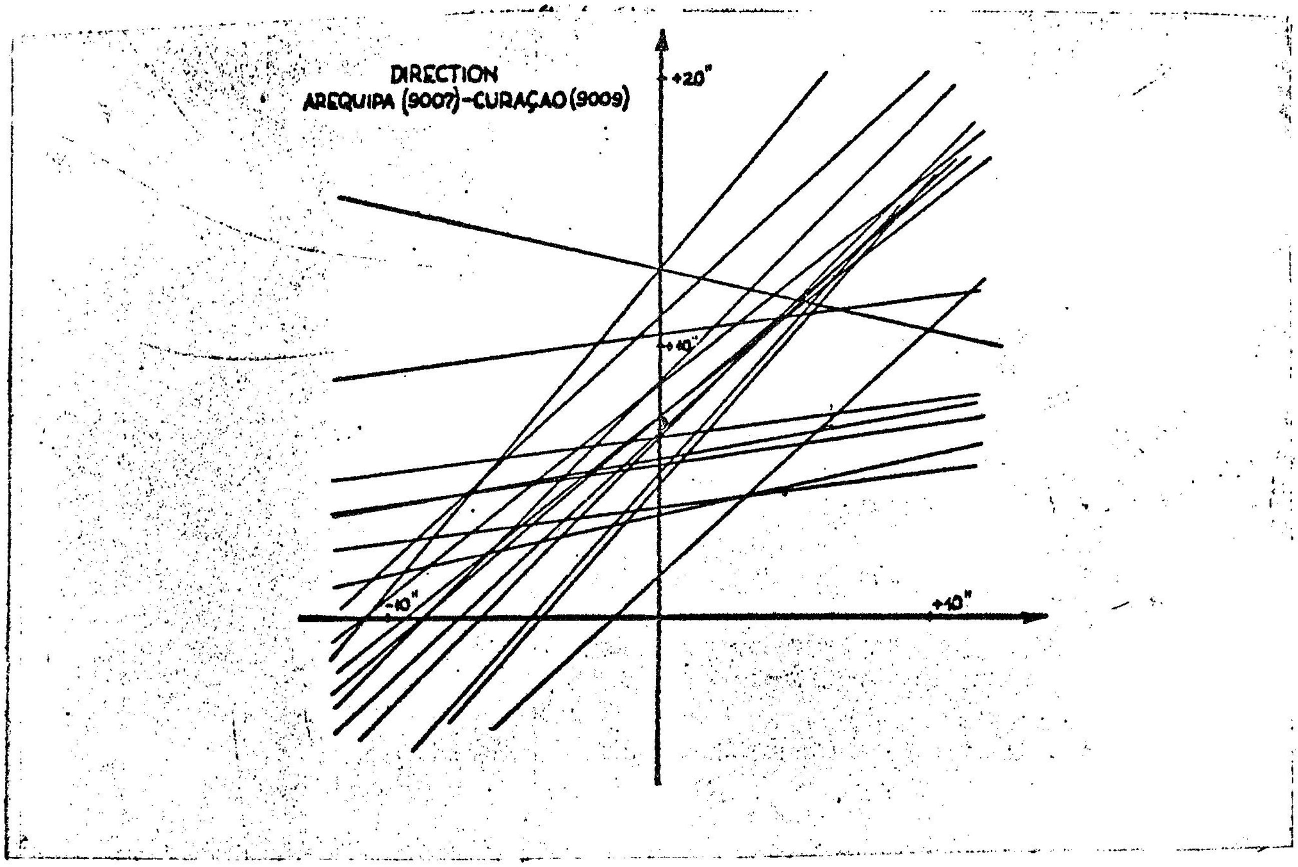

Figure I

Final results in the stellar system of geocentric coordinates for the 25th of October, 1964. A>o to the west; T.U. = $I^h\ 16^m\ 20^s$ following:

9010 - 9009	9007 - 9009
A = $2^h\ 51^m\ 49^s{,}615$	A = $3^h\ 20^m\ 40^s{,}111$
D = $-50^0\ 12'\ 30''{,}07$	D = $+84^0\ 20'\ 47''{,}33$

The determination errors of each direction were:

$m_{A\cos D} = \pm\ 2'',00$	$m_{A\cos D} = \pm\ 1'',68$
$m_D = \pm\ 1'',57$	$m_D = \pm\ 1'',13.$

In unknown stations the point is determined by the intersection of two known straight spaces. Due to observation errors, the intersection of these direct lines also appear in error. We can accomplish this in a graphical manner, selecting a station point in the half of the general perpendicular in such a way that this occurs with the determination of the satellite position [5] by two or more topocentric radius vectors.

We utilize the equation of a directo one:

$$\boxed{\frac{\ell_i}{X_N - X_i} = \frac{m_i}{Y_N - Y_i} = \frac{n_i}{Z_N - Z_i} \quad (i = A, B) \quad /1/}$$

From which follows in linear form:

$$\boxed{\begin{array}{lll} \Delta X n_i - \Delta Z \ell_i + L_{1i} = 0 & A = 9010 & \\ & B = 9007 & /2/ \\ \Delta Y n_i - \Delta Z m_i + L_{2i} = 0 & N = 9009 & \end{array}}$$

where ℓ_i, m_i, n_i - are the directing cosigns of the directions while the free members L_{1i} and L_{2i} are calculated by formulas:

$$\boxed{\begin{aligned} L_{1i} &= (X_N - X_i) n_i - (Z_N - Z_i) \ell_i \\ L_{2i} &= (Y_N - Y_i) n_i - (Z_N - Z_i) m_i \end{aligned}}$$

For two directions we obtain four adjustments for equations with three unknowns. For station 9009 we obtain:

$\Delta X = -54{,}0$ м, $\Delta Y = -4{,}7$ м, $\Delta Z = +17{,}6$ м.

To increase the accuracy of position determination of the stations, one can use a third space direction, determined by the satellite. We decided to calculate the direction Organ Pass 9001 Curcao 9009, however, calculations of these directions are not yet completed.

These same directions were calculated in SAO in an earth geocentric system and published in "Standard Earth" [2]. Below are results of our calculations and the SAO results $\Lambda>0$ to the west. In parenthesis are given the numbers of utilized pairs of simultaneous observations.

Направление 2)	Результаты вычислений 1) своих 3) ours	4) SAO
9010 - 9009	$\Lambda = 9^\circ 35' 19''.54$ $\Phi = -50^\circ 12' 30''.33$ /19/	$\Lambda = 9^\circ 35' 25''.88$ $\Phi = -50^\circ 12' 28''.06$ /176/
9007 - 9009	$\Lambda = 2^\circ 22' 45''.04$ $\Phi = +84^\circ 20' 47''.10$ /18/	$\Lambda = 2^\circ 22' 46''.07$ $\Phi = +84^\circ 20' 44''.38$ /104/

1) calculation results

2) direction

3) hours

4) SAO .

By "Standard Earth" depending on the direction we obtained:

$$\Delta X = -2{,}7 \text{ м}, \quad \Delta Y = +2{,}4 \text{ м}, \quad \Delta Z = +2{,}8 \text{ м},$$

The difference between direction coordinates 9010 - 9009, calculated by us in SAO was large. This is explained by the fact that the larger paralletic angle at the given direction was $27^\circ.2$, while the smaller one was $13^{o}.0$. It is known that this angle influences every adjustment [7]. For the other direction 9007 -9009, these angles corresponded and were respectively $42^{o}1$ and $33^{o}.7$.

From the above mentioned data, it follows that the method insures a suitable accuracy provided that the space directions are well determined and adjusted.

The method is utilized mainly with the transformation of the confirmation of a point from one geodesic system into another. However, these space directions of the given points must be determined at least from two points of a second system.

When it is necessary to determine a station in a geodesic system of two other stations with known coordinates, then the celestial directions are corrected determined by the satellite [6].

$$\boxed{\begin{aligned} dA &= A_G - A_S = \omega + (\varepsilon \cos A + \psi \sin A)\, tg\, D \\ dD &= D_G - D_S = -\varepsilon \sin A + \psi \cos A \end{aligned} \qquad /3/}$$

where $\omega, \varepsilon, \psi$ - are orientation angles in an earlier known geodetic system. In this formula, index G is related to the geodetic values while S is related to the celestial ones.

The calculation method is simple and does not require geocentric coordinates of the satellite, while the computed space directions may be used for other goals of cosmic geodesy. The limited number of geocentric positions with certain transfers or transitions cannot be utilized for other tasks, for example, for the calculation or study of orbits. With the calculation of the direction, there is a possibility to check the computations and the observations [4].

This method also has another advantage: in simultaneous observations with three stations, there is no necessity to sufficiently observe with simultaneity with two stations, which in practice is effected more easily. The observation of directions can be affected in different periods of time, and then calculated for one certain moment.

In these calculations we utilize observations of one satellite which makes the problem easier. These conditions should be investigated more thoroughly, for it is possible that the lines of position obtained from observing a series of satellites with different orbit inclinations sometimes intersect under more advantageous angles.

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